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XXV¹

EXPEDITION OF THE CALIFORNIA ACADEMY
OF SCIENCES TO THE GULF OF
CALIFORNIA IN 1921²

OPISTHOBRANCHIATE MOLLUSCA

BY

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The number of Opisthobranchiate Mollusca collected by the Expedition is unfortunately small, but none the less interesting. The five specimens recorded in the following pages were all collected in the same locality, San Marcos Island, presumably between tide marks, though no data other than locality and date accompany the collector's label.

Family *Aglajidæ* Pilsbry, 1896

Pilsbry, H. A., 1896, Tryon's Manual of Conchology, XVI, p. 43.
= *Doridüda*, Vayssiére, Fischer, et al.

Body oblong, with two dorsal shields separated by a transverse furrow, the head shield having narrow, free, lateral and hind margins; posterior shield or mantle produced backward in two lobes, or wings. Foot wide, truncated in front and behind, the sides continuous into fleshy, parapodial (pleuro-

¹ No. 37 of the Gulf Expedition papers.

² A map showing all the islands, etc., visited by this Expedition will be found in Vol. XII, No. 6, of these Proceedings, copies of which can be supplied for 50 cents.

podial) lobes, which stand erect or recurved at each side of the body. Shell internal, posterior, consisting of a flat, solute, spiral whorl and a minute spire, the inner rim of the whorl calcified, the outer part membranous. Ctenidium posterior, on right side, large, bipinnate. Buccal mass very large, without jaws or teeth. Penis with a superficial sulcus; prostate gland large.

The family at present contains but two genera, *Aglaja* Renier, and *Navanax* Pilsbry, the two being readily distinguishable by the presence of rhinophores at the anterior lateral angles of the cephalic shield in *Navanax*, while they are absent in *Aglaja*. Six species of *Aglaja* are recorded from the West American coast as follows:

1. *Aglaja maculata* (d'Orbigny); Valparaiso, Chile.
2. *Aglaja purpurea* (Bergh); Santa Catalina Island, California.
3. *Aglaja diomedea* (Bergh); Kodiak Island, Shurnagin Is., Alaska.
4. *Aglaja ocelligera* (Bergh); Sitka, Alaska.
5. *Aglaja adellæ* Dall; Eagle Harbor, Puget Sound, Washington.

To this list should also be added the allied genus *Navanax* with the species

6. *Navanax incermis* (Cooper); Santa Catalina Island, San Diego.
7. *Navanax anigmaticus* (Bergh); Bay of Panama.

The present species is distinct from any hitherto described. Since it seemed desirable to preserve the single specimen as fully as possible, the following study is based almost entirely upon external characters, which are amply sufficient to establish its specific independence.

Genus *Aglaja* Renier, 1804

Aglaja Renier, 1804, *Prospetto della Classe dei Vermi*, p. 16, 1807, *Tavole di Classificazione*, Padova, tav. 8; 1847, *Osservazioni postume di Zoologia Adriatica*. Venezia. p. 3, tav. 16.

Doridium Meckel, 1909, *Ueber ein neues Geschlecht der Gasteropoden*. *Beitr. vergl. Anat.*, Bd. I, H. 2, p. 14-33, taf. 6, fig. 12-21, taf. 7, fig. 1-8.

Acera Cuvier, 1810, *Mém. sur les Acères*. *Ann. du Museum d'Hist. Naturelle*, Paris, XVI, p. 9-12, 14-15, Pl. I, fig. 15-20.

Bullidium Leue, 1813, *De Pleurobranchæa novo Molluscorum genere*. *Dissertation*, Halle. p. 10, Nota.

- Lobaria* Blainville, 1825, Manuel de Malacol., p. 478.
Eidothea Risso, 1826, Hist. Nat. Europe Mérid., IV, p. 46.
Posterobranchæa d'Orbigny, 1837, Voy. dans l'Amérique Mérid., p. 201.
Melanochlamys Cheeseman, 1880, On a new Genus of Opisthobranchiate Mollusca, Trans. New Zealand Institute, XIII, p. 224.
Doridium Meckel, Vayssière, 1880, Recherches anatomiques sur les Mollusques de la Famille des Bullidés, Ann. des Sci. Nat., Zoologie, 6 Ser. IX, p. 73.
Doridium Meckel, Bergh, 1893, Die Gruppe der Doridiiden. Mitth. Zool. Station zu Neapel, XI, p. 109-111.

Head shield without rhinophores or frontal processes.

***Aglaja bakeri* MacFarland, new species**

(Plate 11, figures 5-6; Plate 12, figures 12, 16-17)

General body color in the preserved specimen dark brown everywhere, marked with narrow, irregular, longitudinal lines of yellowish white on the cephalic and body shields and on the outer faces of the parapodia. The parapodia are edged with a narrow band of yellowish white, continuous behind across the posterior margin of the foot, but ceasing in front at their anterior ends. Near the parapodial margin on their outer face is a row of ocelli, composed of light blue, rounded or elliptical spots, each edged with a narrow band of black, the largest measuring circa 0.5 mm., in length. These submarginal ocelli, some 60 in all, are arranged at fairly regular intervals in a single series, extending the full length of the parapodial lobes, and across the posterior edge of the foot, but cease in front with the parapodia themselves. The external surface of the parapodia is of a slightly darker brown ground color than the dorsal areas, gradating below into a bluish black. Upon this background are borne some 17 to 20 narrow, longitudinal lines of yellowish white, occasionally interrupted, or broken into short dashes or dots. These lines are independent of each other in the main, but occasionally branch, or run together, widening out into elongated blotches. The inner surface of the parapodia is of an uniform light brown color, becoming darker below, though the unsatisfactory preservation of the inner faces makes details obscure. Posteriorly, in the gill-region, numer-

ous very minute scattered ocelli may be made out with a lens, in each a central spot of brown being surrounded by a narrow halo of yellowish white.

The foot has a general ground color similar to the rest of the body, but deepening into a bluish black in its anterior half. It is everywhere thickly strewn with rounded, sharply defined, yellowish white spots, the largest ones arranged in a single, longitudinal, median row (Plate 11, figure 6). These may reach a length of 1.0 mm., the majority, however, not measuring more than 0.5 mm. in diameter. Other than the median series the distribution of these spots is irregular. Occasional double spots, caused by fusion, are not uncommon. The anterior margin of the foot is thick and fleshy, and slightly notched in the median line. The edge is squarish, darker in color, and bears a single series of rounded, closely set spots, similar to those of the general ventral surface.

The ground color of the cephalic shield is dark brown, deepening at the anterior thickened border to blue black; some 16-20 narrow, longitudinal lines of yellowish white, the number decreasing to about 12-14 behind, extend lengthwise of the shield (Plate 11, figure 5). But few of the lines are continuous throughout their whole extent, being more frequently interrupted or branched. Scattered dots and dashes also appear at intervals between the lines, and local widenings, affecting several adjacent lines, and occasionally causing slight fusions, give rise to local, lighter areas. At the posterior margin the lines widen, and merge into an indistinctly defined, light yellow zone, which also edges the sides of the shield. In front the thick, black edge of the shield bears an irregular series of closely set, yellowish white spots, similar to those of the anterior foot margin, immediately below.

The ground color of the posterior shield, or mantle, is light brown, relieved by narrow, longitudinal lines of yellowish white, similar to those of the cephalic shield, but wider. They are also broken into rows of dots, or interrupted at intervals, and are subject to local widenings. About midway of the length of the mantle a transverse zone of such local widenings gives rise to a light band, extending across the whole width

of the mantle, as may be seen in figure 5 of Plate 11. Some 20 such lines may be counted toward the anterior margin of the mantle, the number increasing to over 35 in the posterior region. The posterior prolongations or lobes of the mantle are darker brown, the inner surface being dotted with light spots.

The sides of the body below the cephalic and somatic shields are light yellowish brown, deepening in front to nearly black. They bear numerous, elongated spots of yellowish white, all tending in a transverse direction. Similar transverse spots are continued in the groove between the shields, and behind the surface is everywhere flecked with smaller, white spots.

The general body form (Plate 11, figures 5 and 6) is elliptical in outline, plump and fleshy, strongly contracted by the killing agent, and now probably measuring not more than one-half the length in life. Length over all 14.5 mm., the greatest width 9.6 mm. and the greatest height 10.2 mm. The ventral foot area is rounded laterally, curving upward into the low parapodia with no sharply defined boundary (Plate 11, figure 6). The anterior margin of the foot is rounded at the angles, the strong contraction of the foot, immediately behind, causing them to project as rounded lobes, accented by the moderate notch in the median line. Immediately behind the anterior angles the sides of the foot are prolonged upward in the low, wing-like parapodia, which attain their maximum height of 5.7 mm. midway of the body length, thence narrowing to a low, thin expansion, 2.0 mm. in height, continuous across the posterior edge of the foot and uniting behind in the median line.

The cephalic shield, quadrangular in form, 10.0 mm. in length by 7.0 mm. in width, covers nearly one-third the length of the convex dorsal surface. Its anterior margin is thickened, in part due to contraction. The anterior, outer angles are prominently rounded and thickened, but do not show the peculiar short, inrolled tentacles, described by Bergh ('94) for *Navanax aenigmaticus* (Bergh) from Panama. The lateral and posterior margins are free, the latter overlapping the posterior shield, the former are concealed behind the edge of the parapodia.

The posterior body shield, or mantle proper, is of a general elliptical outline, set off from the rest of the body surface by a distinct margin with smooth outline (Pl. 11, figures 5 and 6). In front it is rounded and narrower, attaining its greatest width about midway of its length. Posteriorly it narrows into two thickened, triangular lobes, united by their bases above, but below separated by a circular opening, for which they form an incomplete boundary. This aperture forms the posterior opening of the pallial chamber, a roomy, triangular cavity beneath the right, posterior part of the mantle shield, and containing the branchial plume, the renal and anal openings. Its dorsal lining is deeply pigmented, the remainder is colorless or nearly so. The basal portion of the posterior lobes and the mantle immediately in front of them contain the spiral shell, the calcareous apex and central portion being prolonged upward and forward into the thin, membranous anterior part. In Plate 12, figure 12, the mantle lobes are reflected against the hinder surface of the dorsum to disclose the posterior opening of the pallial chamber, though in life they are directed backward. The right lobe appears to be a trifle larger than the left one, but no trace of a flagellum or similar prolongation of the left lobe is present, though it is a structure characteristic of many of the Aglajidæ. The total length of the mantle, exclusive of the two posterior lobes, is 16.0 mm., its maximum width is 12.0 mm., while the lobes themselves reach a length of 3.0 mm.

The ctenidium is a large, crescentic plume, lying in the anterior half of the pallial chamber. It consists of a flat, triangular, plate-like axis, continuous at its broad, proximal end with the ventral wall of the mantle cavity, to which it is attached in front and behind for ca. 3.5 mm., thence projecting as a free plume, curving around below the right, posterior mantle process. The dorsal and ventral surfaces of this plate bear triangular lamellæ, which are in turn lamellate, thus forming a bipinnate gill, the most complex and highly developed of these lamellæ being found near the boundary of the attached portion, where they reach a height of 1.5 mm. Fifteen or sixteen of these branched lamellæ are found on the dorsal face of

the plume, nearly as many occupying its ventral face. In the free portion the plume is so rotated that the dorsal lamellæ are directed forward in the specimen at hand (Pl. 12, fig. 12). The size of this figure precluded any attempt to show the detail of the branching of the lamellæ, and, furthermore, it is much clearer in that portion of the plume which is concealed beneath the mantle rather than in the exposed part. The anterior and posterior margins of the rhachis are occupied by the efferent and afferent vessels respectively. The whole plume is pale, yellowish white in color, with a few dark flecks scattered along the rhachis and the margins of the dorsal lamellæ.

Immediately behind the base of the plume and slightly to the right of the median plane is the anal opening. In front of it, and at a slightly higher level, is the minute, renal pore. Directly below the anterior attachment of the ctenidium to the body wall is the posterior genital opening, a vertical slit with a yellowish, posterior margin. From its lower end the clearly marked, spermatic furrow, a narrow groove with prominent margins, leads forward along the body wall, immediately above the origin of the right parapodium, to the penis opening at the extreme anterior, right side of the head. The furrow is edged throughout its entire length by a narrow line of black.

The shell (Pl. 12, figs. 16-17) consists of a posterior, narrow, calcified portion, expanded in front and at the left into a large, thin, membranous extension. The calcified part is made up of a minute spire, directed downward and backward, and a solute, falciform whorl, terminating near the right, posterior margin of the mantle in a blunt tip. The posterior, left portion of the whorl is flattened, the remainder is strongly convex. Upon the posterior surface of the spire a distinct crest is borne, which dies away as it continues forward. The hinder border of the whorl is strongly thickened as it becomes free from the spire, and thence thins away into an increasingly reflected margin toward the right. The anterior border of the calcified area (Pl. 12, figs. 16-17, *a*) is irregular, presenting a deep and narrow notch (possibly abnormal) near the left border of the shell, on the right side running parallel to the posterior border in general. In front it is continuous with the

less convex, thin, transparent, membranous portion, widest on the left, and narrowing rapidly toward the right to less than half the width of the calcified portion, the tip of which it surrounds. Strongly marked lines of growth are evident throughout both areas of the shell. The general color of the calcified portion is a light yellow, deepening somewhat in the thicker portions. Its maximum transverse width is 4.7 mm., its maximum length is 4.4 mm., of which latter measurement the calcified portion comprises 1.6 mm., and the membranous portion 2.8 mm.

As usual in the genus the large pharyngeal bulb was destitute of both mandibles and radula.

Type: No. 1736, Mus. Calif. Acad. of Sci., collected May 12, 1921, at **San Marcos Island, Gulf of California**, by Dr. Fred Baker, to whom the species is dedicated in recognition of his untiring, scientific activity and interest.

Family **Aplysiidæ** Blainville, 1825

Animal lengthened, not protected by a shell, the neck and head narrower than the body; mouth a vertical fissure; anterior angles of the head produced into two, tentacular lobes folded above, behind them the cylindrical or conical rhinophores, slit above, in front of which are the minute eyes. Parapodia recurved over the back, forming two, lateral or dorsal lobes enclosing the mantle and ctenidium. Genital orifice between the dorsal lobes, communicating by a long furrow with the eversible penis, which is near the right tentacle. Shell nearly or entirely covered by the mantle, uncoiled, in the form of a concave plate, sometimes absent. Mouth with corneous jaws and a large, multiserial radula, composed of similar teeth; stomach armed with horny nodules; anus behind the branchial plume.

Genus **Tethys** Linnæus, 1758

Tethys Linnæus, 1758, Syst. Nat. Ed. 10, p. 655.

Laplysia Linnæus, 1767, Syst. Nat. Ed. 12, p. 1089.

Aplysia Gmelin, 1791, Syst. Nat. Ed. 13, I, VI, p. 3103.

Tethys, Pilsbry, 1895, Proc. Acad. Nat. Sci. Phila., p. 347; Pilsbry, 1896, Tryon's Man. Conch., XVI, p. 65.

Animal swollen behind, narrower in front, with rather long neck and head, bearing folded tentacles and slit rhinophores as usual in the family, the latter about midway between tentacles and parapodia. Parapodia arising in front of the middle of the animal's length, ample, freely mobile, free throughout their length, or united for a distance behind, functional as swimming lobes, anterior ends separated. Mantle nearly covering the ctenidium, having a median tube, foramen, or orifice communicating with the shell cavity, and produced behind in a more or less developed lobe or lobes, rolled to form an excurrent siphon. Genital orifice under front edge of mantle, in front of ctenidium; hypobranchial gland present, a short distance behind the genital opening. Foot well developed.

Shell very thin, membranous, with a thin, calcareous, inner layer, nearly as large as the mantle, concave, with pointed, small apex bearing a recurved lamina, and having a concave, posterior sinus.

The species of *Tethys* recorded from the Panamic Province are:

1. *Tethys panamensis* Pilsbry; Panama.
2. *Tethys robertsi* Pilsbry; West Coast of Mexico.

From the adjoining Peruvian Province five species are known:

1. *Tethys nigra* (d'Orbigny); San Lorenzo Island, Peru.
2. *Tethys rangiana* (d'Orbigny); Payta, Peru.
3. *Tethys lessoni* (Rang); Payta, Peru.
4. *Tethys inca* (d'Orbigny); Callao Bay, Peru.
5. *Tethys chierchiana* (Mazzarelli & Zuccardi); San Lorenzo Island, Peru.

The Californian forms at present listed are:

1. *Tethys californica* (Cooper); Monterey to San Pedro.
2. *Tethys ritteri* Cockerell; San Diego.

To the Panamic forms is to be added the Antillean species studied in the following pages, having been taken by the expedition at San Marcos Island. Without doubt further collect-

ing in the region will bring to light other species than those listed.

Tethys parvula (Guilding ms. Mörch)

(Plate 11, Figures 1-4; Plate 12, Figures 1-11)

Aplysia parvula Guilding ms., Mörch, 1863, Contributions à la Faune malacologique des Antilles danoises. Journal de Conchyliologie, Sér. 3, III, p. 22-23.

Tethys parvula (Guilding) Mörch, Pilsbry, 1896, Tryon's Manual of Conchology, XVI, p. 83-84, Pl. 37, f. 23-25.

Tethys parvula (Guilding) Mörch, Dall & Simpson, 1902, Mollusca of Porto Rico, Bull. U. S. Fish Comm., XX, Part I, p. 366, Pl. 53, f. 14.

Tethys parvula, the smallest species of the genus, has thus far been recorded only from St. Thomas, St. Vincent, and the Caballo Blanco Reef off Vieques Island, all in the Lesser Antilles. To find it nearly 50 degrees to the westward in the Pacific Ocean, without any record of intermediate occurrence is somewhat surprising, but illustrates again the paucity of our knowledge concerning the distribution of the Opisthobranchs. Without doubt it is of wide occurrence in the Caribbean Province, and is here added to the Panamic fauna as well by the Academy Expedition. Some 52 living Molluscan species have been verified by Mrs. Ida S. Oldroyd as either living at present in both these Provinces, or as having formerly so existed. These are survivals of the forms which, probably in the Oligocene, were able to pass through the open sea connecting the Atlantic and the Pacific oceans in this region. As yet uncertainty exists concerning any later connection between the two oceans. "As far as now known the Miocene was a period of elevation all through this region, and no strictly Miocene marine strata have as yet been identified." (Prof. W. H. Dall in letter to Mrs. Ida S. Oldroyd). The view held by Vaughan ('17), based upon a study of the reef corals of the upper Gulf of California, would indicate an interoceanic connection scarcely later than the lower Pliocene, but his evidence seems insufficient to Dickerson ('17) among others, who places

the latest connection as in Miocene time. In the absence of recorded fossils of any of the Aplysiidæ, the distribution of this present species is at present the only evidence we have of the age of the group.

The three specimens (Pl. 11, fig. 1-4) are all strongly contracted in the head and tail regions, and the epidermis everywhere is softened and more or less detached, so that details of the coloration are but poorly preserved, though the characteristic features of the species are unmistakable. The body form is somewhat prismatic, slightly higher than wide, soft, the anterior tentacles are strongly contracted, the wide, short head bears two, moderate, inrolled rhinophores, their bases close together, separated by a distance of from 1.0 to 1.2 mm. The eyes are faintly visible through the integument in front of the bases of the rhinophores, and are slightly nearer to them than to the anterior tentacles. The parapodial lobes are large and fleshy, their anterior ends widely separate and auriculate, projecting forward as a free, rounded lobe above the point of union with the body (Plate 11, fig. 1). Behind the parapodia are continuous, closely enclosing the relatively large shell, which is conspicuous through the very large, thin-edged mantle foramen, 2.8 mm. long by 2.4 mm. wide. The mantle margin projects slightly in front and on the left side, while on the right it overlies the deep branchial chamber.

The ground color of the animal is light brown, clouded and mottled irregularly with darker shades; the sides of the parapodia, the top and sides of the head and tail are thickly set with small, rounded spots of light yellow, or, rather, these spots are destitute of pigment and the translucent yellow of the underlying tissues shows through. The margin of the mantle foramen, the margin of the parapodia, the anterior margin of the foot, the anterior margin of the head and the anterior tentacles are all bordered with a narrow zone of intense black. This black marking is identical with that found by Dall and Simpson ('02).

The foot is so strongly contracted that its details are obscure. The tail region is short and broad, and the anterior margin shows a distinct, median notch.

The shell (Pl. 12, figs. 7-10) is very large in proportion, but does not cover the whole animal, as stated by Dall and Simpson. It is strongly convex, rather thick, calcareous, oval in general outline, narrowing behind. Its margin is uncalcified, thin and membranous, broadest in front and along the left, anterior side, decreasing at the sinus region, and continuing over the apex as a scarcely discernible, narrow band (Pl. 12, figs. 7-10). The concentric lines of growth are very distinct, forming between them slight ridges, readily visible when seen in profile in favorable illumination and magnification (Pl. 12, fig. 7). The apex is strongly incurved, involute and thickened, with the reflexed margin prolonged as a narrow band over the tip (Pl. 12, fig. 9). The posterior sinus on the right is strongly concave, as seen in side view (Pl. 12, fig. 7). The color of the shell is pale amber to reddish and the inner surface is slightly iridescent. In the animal measuring 9.2 mm. in total length the shell dimensions were as follows: length 5.0 mm., width 3.4 mm., height 1.7 mm., length of sinus 1.6 mm. These measurements agree closely in proportions with those given by Pilsbry ('96), and by Dall and Simpson ('02), though their specimens were considerably larger. The oval mantle foramen, through which the shell is visible, is very large in this species, disclosing over one-third the area of the shell. *T. rangiana* (d'Orbigny) from Peru also possesses this characteristic, but is otherwise distinct.

The ctenidium lies transversely in the pallial chamber, below the anterior half of the shell and mantle. It is of somewhat triangular form, attached by its anterior and posterior margins, the tip projecting below the mantle to the right.

The right posterior margin of the mantle is inrolled and continued above the sinus of the shell, forming a very short and rather wide siphon, leading outward from the pallial chamber. Into it on the left side opens the anal tube, and below and in front of the latter is the inconspicuous, renal opening. At the anterior end of the pallial chamber, opposite the end of the right parapodium is the posterior genital opening. From it the narrow, spermatic furrow leads downward and forward,

below the right rhinophore to the external opening of the penis sheath, below the right tentacle at the side of the head. Immediately behind the posterior, reproductive opening is an area, some 2.2 mm. long, through which open the cells forming the hypobranchial, or opaline gland, the so-called Organ of Bohadsch. The organ as seen from within (Pl. 12, fig. 11) is made up of a group of closely set, gigantic, unicellular glands with dilated, ends, projecting freely from the integument. The most of these are of the diffuse type, each cell opening independently through the integument, but at the anterior end of the group is a cluster of cells (Plate 12, fig. 11a), which seem to open into a common duct. A detailed study of this structure with serial sections of properly fixed material would prove valuable, since this species seems to unite two distinct types of opaline gland structure, the diffuse and the compact, hitherto found separately in widely different species.

The chief measurements of the three specimens at hand may be tabulated as follows:

	Specimen No. 1	2	3
Length over all.....	7.8 mm.	9.1 mm.	9.2 mm.
Maximum width	4.5 "	3.9 "	4.6 "
Maximum height	4.7 "	5.1 "	4.0 "
Length of parapodia.....	4.8 "	5.0 "	5.3 "
Length in front of parapodia.....	——	2.7 "	2.3 "
Width between anterior ends of parapodia..	2.8 "	2.1 "	3.4 "
Width between rhinophores.....	1.0 "	1.2 "	1.0 "
Length of shell foramen.....	3.0 "	3.6 "	3.2 "
Width of shell foramen.....	2.7 "	3.0 "	2.0 "

The pharyngeal bulb has the form of a truncated, four-sided pyramid. It is 2.2 mm. long by 1.9 mm. in maximum width and height, tapering to 1.2 mm. at the anterior end. It is continued in front to the mouth opening by a short, thick walled, oral tube. At the median, posterior surface the rounded end of the radula sack is visible, but it does not project beyond the general surface of the bulb. The opening from the oral tube into the bulb is a vertical slit, 0.6 mm. long, in the center of an oval, cuticular disk, pigmented with dark brown at the margins

and becoming lighter yellow within. The sides of the opening are guarded by the large, mandibular rodlet areas or plates. These (Pl. 12, fig. 6) nearly meet in the median line above and below, are somewhat triangular in form, broadest (0.7 mm.) above, the anterior margin 0.9 mm. long and slightly curved, the posterior one deeply so, the width at the ventral side decreasing to one half that of the dorsal border of the armature. Each mandibular plate is made up densely packed cylindrical rodlets, longest at the anterior margin and decreasing progressively in length posteriorly. The individual rodlets (Pl. 12, figs. 4 and 5) are slightly curved or nearly straight elements, the tips being directed slightly forward. Each of the rodlets is the cuticular product of a single epithelial cell (MacFarland '18). The greatest length attained by these rodlets is 0.041 mm., their width averaging 0.0055 mm.

The light amber radula is broad, and moderately grooved in the median line. It occupies the posterior face of the muscular rotula, curving forward upon its upper surface, while below its sides converge into the somewhat cylindrical, short radula sack. At its anterior end the radula narrows abruptly to the width of the median groove alone, the oldest row of teeth being represented by the single rhachidian one. The total length of the radula is 2.1 mm., its maximum width 1.6 mm. The teeth are arranged in twenty-six rows, of which twelve are functional at the anterior end, and fourteen are inclosed in the sheath, the last one being rudimentary. Each row is made up of a single, median tooth and ten to twelve laterals on each side, the outermost two or three of which become reduced to flattened plates, the dental formula hence being expressed as 26 (10-12 . 1 .10-12). The number thus indicated is the smallest yet recorded for any Tethys, and rather appropriately is found in the smallest species of the genus. The median tooth and a complete half-row are shown in figure 1 of Pl. 12, and the same elements are represented in basal view in figures 2 and 3 of the same Plate.

The median tooth (Pl. 12, fig. 1, *c*) is broad and strong, its base (fig. 2) a trapezium in form, its posterior, outer angles

produced in wide spreading, rounded prolongations. The median cusp is broad and strong and bears on either margin a series of six to seven denticulations, the largest nearest the base, the remainder decreasing progressively in size toward the tip of the cusp, the outermost being reduced to mere serrulations in many teeth. Lateral to the median cusp on either side is borne another cusp of similar form, but of half its length. The margins of this first lateral cusp are either minutely serrulate or entirely smooth, the outer margin frequently showing a narrow, shelf-like lamina along its lower border. A second, lateral cusp of similar form, but of approximately one-half the size of the first lateral succeeds it outwardly, and indications of a third, minute, rudimentary, external cusp may also be found in some rhachidian teeth. The dimensions of these structures as found in two typical rows, the 11th and the 22d, may be tabulated as follows:

	Eleventh row		Twenty-second row	
	Length	Width	Length	Width
Median cusp	0.033 mm.	0.042 mm.	0.042 mm.	0.042 mm.
1st. lateral cusp.....	0.015 "	0.018 "	0.021 "	0.024 "
2d. " "	0.008 "	0.012 "	0.012 "	0.010 "
Base of tooth.....	0.090 "	0.216 "	0.096 "	0.198 "

The lateral teeth are arranged in an oblique series with reference to the rhachis of the radula. The contours of the bases of the lateral teeth shown in figure 1 of Pl. 12 are drawn in fig. 3 of the same Plate. The first of the row (1) is broad in front, obliquely triangular, with all the angles rounded, the others narrow and decrease in size progressively, the triangular form being soon replaced by an elongate one. From the anterior end of the first lateral (Plate 12, fig. 1-1) a strong hook arises, bearing a large, denticulate, median cusp, a single, smaller, smooth margined, inner cusp, and a series of three, outer ones decreasing in size, all having smooth margins. A comparison with the median tooth shows a striking similarity, the latter apparently being made up from the fusion of two, symmetrical laterals in the median plane, the inner cusp of the laterals being lost in the process. The successive

laterals beyond the first present the same general form, decreasing in size and complexity, and finally in the outer three becoming reduced to oblong, slightly thickened plates, destitute of a hook, or with but a faint rudiment of such at the anterior end. A comparison of the different teeth shown in fig. 1 of Plate 12 will render these and other details more evident than through a long description.

Three specimens of this species were collected at San Marcos Island, Gulf of California, by Dr. Fred Baker, on May 12, 1921. One of these was dissected in making the foregoing study, and the preparations made from it, together with the other two, are deposited in the collections of the California Academy of Sciences.

Family Elysiidæ Gray, 1857

Body form flattened, with lateral, leaf-like expansions, separated from the dorsum by a distinct, elevated line. Head narrow, rather high in front; tentacles short, auriform, involute. Genital openings behind the right tentacle. Behind the head the large, reno-pericardial prominence, with the anal opening at its right side, or posterior in the median line.

Foot obscurely set off from the body, in front transversely divided into two parts, its anterior angles slightly prominent.

Pharyngeal bulb suctorial, but without prominent ingluvies. Radula uniserial, the teeth large, compressed, dagger-like, usually serrulate or finely denticulate below.

Hermaphroditic and accessory reproductive glands greatly ramified throughout the lateral processes of the body. Penis unarmed.

Genus *Tridachia* Deshayes, 1857

Tridachia Deshayes, 1857, Journal de Conchyliologie, II Sér. II, p. 141.

Pterogasteron Pease, 1860, Proc. Zool. Soc. London, XXVIII, p. 35.

The genus *Tridachia* Deshayes is closely related to *Elysia* Risso, but differs in the extraordinary development of the para-

podia, which possess very long and undulating margins ("profondement contournées à la manière des feuilles de laitue," Deshayes), from which fancied resemblance to a lettuce leaf the generic name arises. The anterior ends of the parapodia are also united to each other behind the head and in front of the reno-pericardial elevation. Posteriorly the narrowing parapodia are continued to the tip of the tail, where they fuse. The sack at the anterior end of the radula, inclosing the discarded teeth, is but little developed. To this genus belong the genotype *Tridachia schrammi* Deshayes, and *Tridachia crispata* (Oersted, Mörch), both from the Antilles.

In the collections made by the "Albatross" in 1891 in the Gulf of California Bergh ('94) found two specimens, which he doubtfully described as *Tridachia ? diomedea* Bergh, owing to the fact that the parapodia did not unite in front as in the genus *Tridachia*. The Academy expedition of 1921 brought back a specimen from San Marcos Island, which is clearly the same as the form described by Bergh. It is equally evident that the parapodia do not unite in front behind the head, so that it cannot belong to the genus *Tridachia* as originally constituted. Bergh's ('72) earlier studies of *Tridachia crispata* (Oersted, Mörch), based upon the original specimens of Mörch, together with other specimens from the Antilles, leave no doubt as to the validity of the character for that genus. The only alternative then is to erect a new genus for the Gulf of California form, which is here proposed.

Tridachiella MacFarland, new genus

Head rounded above, with large inrolled tentacles; anus anterior latero-dorsal. Lateral expansions of the body wide, their margins greatly plicated and sinuous, the anterior ends approaching each other dorsally, in front of the reno-pericardial elevation, but not uniting.

Tridachiella diomedea (Bergh)

(Plate 10, Figures 1-3; Plate 12, Figures 13-15, 18-21)

Tridachia ? diomedea Bergh, 1894, Die Opisthobranchien, Bull. Mus. Comp. Zool. Harvard, XXV, 10, p. 194-5, Taf. I, f. 1-7.

The animal, preserved in formalin, seemed but slightly contracted, save possibly in the rhinophore region. The body length over all, from the anterior margin of the head to the tip of the tail, measured 35.4 mm. The greatest width, with the parapodia in their reflected position as preserved, is 14.3 mm., of which measurement 8.3 mm. forms the body proper. With the parapodia carefully flattened out horizontally the maximum width was 20.3 mm., the actual dimensions of the living animal probably exceeding these considerably.

The general body form, strikingly similar at first glance to a polyclad worm, is well shown in figures 1, 2 and 3 of Plate 10. The head is well developed, extending 4.0 mm. in front of the anterior margins of the parapodia. The rhinophores are relatively very large, 3.2 mm. in length by 2.0 mm. in antero-posterior and 1.8 mm. in transverse, maximum diameter. These dimensions are of course somewhat less than in the living animal, and are subject to variations, since the rhinophore consists of an inrolled, flattened plate (Pl. 12, fig. 21) the anterior margin slightly overlapping on the outer face.

The ground color of the preserved specimen is everywhere pale yellow to translucent grey. The margins of the parapodia bear a single row of velvety black, triangular or rounded spots, borne alternately on the outer and inner surfaces, slightly below the edge. Toward the tip of the tail these spots become closer together and finally coalesce into a black band, some 2.0 mm. in length, parallel to and bordering the inner and outer margin of each parapodium, and uniting at the tip of the tail. Traces of orange yellow are recognizable along the outer border of the parapodia in the edging of the most anterior lobe, which is directed transversely across the back toward its fellow of the opposite side. Minute flecks of black are also scattered sparsely over the dorsum and both surfaces of the parapodia.

The inner surface of each rhinophore is almost entirely black, and the outer surface is irregularly banded transversely with the same color.

The foot (Pl. 10, fig. 3) is fairly well set off from the sides of the body, which rise above it, by a faint groove. It is divided into a shorter, anterior portion, 6.0 mm. in length, and a longer portion by a shallow, transverse groove. Its total length reaches 33.7 mm., its anterior end is dilated to 5.3 mm., thence narrowing rapidly to 3.0 mm. at the junction of the anterior and posterior areas, widening gradually again to 3.7 mm., midway of the body length, from which point it narrows slightly to the short, blunt tail. The anterior angles are bluntly rounded and prominent, with a wide notch in the median line of the foot separating them.

The parapodia extend the full length of the body from the neck region to the tip of the tail. They are thrown into six, main folds, the free margin being much longer than the basal line of insertion in the side of the body. These folds are in turn convoluted into a great number of smaller folds, the whole presenting the appearance of an elaborate ruffle (Pl. 10, figs. 1 and 2). The anterior ends of the parapodia curve inward toward the median line (Pl. 12, fig. 20), but do not meet, each terminating in a small lobe and leaving a narrow, mid-dorsal space free, 1.0 mm. in width. The anterior termination of the parapodia is 2.0 mm. behind the base of the rhinophores.

The mouth opening is small, oval in outline (Pl. 10, fig. 3) and is situated at the lower end of a median furrow, which is prolonged upward between the bases of the rhinophores as a shallow depression. A transverse furrow separates the mouth region from the anterior end of the foot.

The eyes (Pl. 12, figs. 20 and 21) are conspicuous small black bodies, 2.5 mm. apart, immediately behind the bases of the rhinophores, below the integument.

The reno-pericardial elevation (Pl. 12, fig. 20) forms a prominent, oval area in the anterior, mid-dorsal region, immediately behind the anterior ends of the parapodia. Behind it the mid-dorsum becomes concave, extending thus to the tip of

the tail. The reno-pericardial prominence is 3.5 mm. long by 2.0 mm. wide, and from its posterior end on either side an elevated ridge marks the course of a vessel, passing backward and outward along the base of the parapodium, to which it sends off branches at intervals. From the anterior, left side of the elevation a similar ridge arises, at once dividing into two divergent branches, which pass to the anterior portion of the left parapodium. On the right side a similar branch appears, subdividing a little farther from its origin, and having a like distribution. These ridges presumably contain ramifications of the liver tubules.

Immediately in front of the right, anterior ridge just described, and slightly toward the median line is the anal opening, Pl. 12, fig. 20, *a*. Slightly behind the middle of the reno-pericardial prominence, on its right side, is located the inconspicuous renal opening, *r*. Just in front of the anterior end of the right parapodium as it curves inward is the opening of the oviduct, Pl. 12, fig. 21, and slightly above and behind it is an obscure opening, which I identify as the vaginal aperture, though certainty could not be attained save by complete dissection, or, better, by serial sections, and it was not desirable under the circumstances to injure the specimen more than absolutely necessary. At the outer base of the right rhinophore is situated the external opening of the penis, concealed in fig. 21 of Pl. 12 by the upturned, and slightly swollen margin of the foot. In Bergh's ('72) account of *Tridachia crispata* he figures in Pl. XXI, f. 14, *a*, *b*, the opening of the oviduct as situated in front of the base of the rhinophore and the penis sack opening, while his description locates it behind the latter. He apparently did not find the vaginal opening at all, its recognition in *Elysia* being due to Pelseneer ('94) much later.

The ellipsoidal, pharyngeal bulb is surprisingly small for such a large animal, measuring not more than 1.4 mm. in length by 1.0 mm. in height. Its short mouth tube is surrounded by a thick, cushion-like mass of oral glands. The posterior salivary glands form a closely branched, alveolar mass on either side of the oesophagus, extending backward be-

tween it and the retractor muscles of the bulb to the stomach region. Their ducts pass through the nerve collar and each dilates into a small, spherical ampulla, just before entering the posterior wall of the pharyngeal bulb, close to the emergence of the oesophagus. The upper half of the bulb is strongly muscular, 18-20 transverse bands of muscle being conspicuous upon its dorsal surface. Its cavity, however, is relatively simple and there is no indication of an even partially separated, dorsal ingluvies, or suctorial cavity. No trace of a differentiation of any mandibular apparatus is present within the opening of the mouth tube into the bulb. The cavity of the whole bulb is lined by a well developed cuticle, which is reflected around the mouth margin and thins away in the oral tube, while behind it is prolonged into the oesophagus. From the ventro-median surface this cuticle is prolonged downward as a cylindrical sack, clothing the radula sheath, and in the anterior wall of this sack the radula itself is differentiated as a cuticular modification. The anterior end of the radula is prolonged downward as a similar tubular, cuticular evagination, the lower end of which dilates into the characteristic ascus of the *Ascoglossa*, in which the cast-off teeth from the anterior end of the radula are preserved, instead of being shed free in the cavity of the pharyngeal bulb.

The radula is narrow, small and compressed, making a sharp angle in the anterior portion of the bulb, its ends not making any projection beyond the lower surface of the organ. Pl. 12, fig. 13, illustrates the three teeth nearest the angle in the front limb and the upper one at the top of the sheath in the posterior limb. Evidently but few of the teeth are functional at the same time, the one at the angle and those immediately in front of it being probably all that are in use. At the bottom of the anterior limb in the ascus are three, loose, discarded teeth, another, just freed from its attachment, is at the entrance to the sack, the anterior limb of the radula contains eight still attached by their bases, and the posterior limb, or radula sack, in which the teeth are formed, ten more, making twenty-two in all. Fig. 14 of Pl. 12 represents the third, discarded

tooth as seen obliquely from below. All the teeth are of practically the same size throughout the radula, each measuring 0.195 mm. in total length, of which 0.105 to 0.112 mm. make up the length of the spine. The height of the top of the tooth above the base is 0.075 mm., and the length of the base itself varies from 0.8 to 0.10 mm. The base is moderately thick and wide, its ventral surface is concave, and the ends are rounded. Upon it is borne a strong spine or hook, nearly straight, the tip being slightly curved downward. Seen from above this spine is somewhat broad and shaped like a two-edged dagger. No denticulations were found upon its lower surface. Upon the dorsal surface of each tooth is a wide depression, into which the spine of the succeeding tooth fits exactly, as seen in outline in fig. 15 of Pl. 12, which is represented as if transparent. The lateral walls of this depression flare out at the posterior ends in short, wing-like processes, seen in side view in figure 15 and in oblique view from the rear in figure 14.

The central nervous system (Pl. 12, figs. 18 and 19) is made up of the paired, fused cerebro-pleural, the pedal, parietal and buccal ganglia and the large unpaired visceral ganglion, closely united in a group surrounding the oesophagus, in contact with the posterior face of the pharyngeal bulb. The optic nerves are very long as indicated in the figure. To identify and trace out the distribution of the nerves in an adequate manner was impossible, without completely destroying the specimen, so no further dissection was attempted.

One specimen, collected by Dr. Fred Baker at San Marcos Island, Gulf of California, May 12, 1921, preserved in the Museum of the California Academy of Sciences.

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EXPLANATION OF PLATES

The figures of Plates 10 and 11 are reproduced from photographs of the specimens; those of Plate 12 are from drawings made by Mrs. Olive H. MacFarland, from preliminary camera lucida sketches by the author.

Plate 10

Figs. 1-3. *Tridachiella diomedea* (Bergh).

- Fig. 1. Oblique view of the animal as seen from the right and above. X 2.
Fig. 2. Dorsal view. At the right the non-union of the parapodial ends behind the head is evident. See also Plate 12, figure 20. X 2.
Fig. 3. Ventral surface as seen slightly obliquely from the right. X 2.

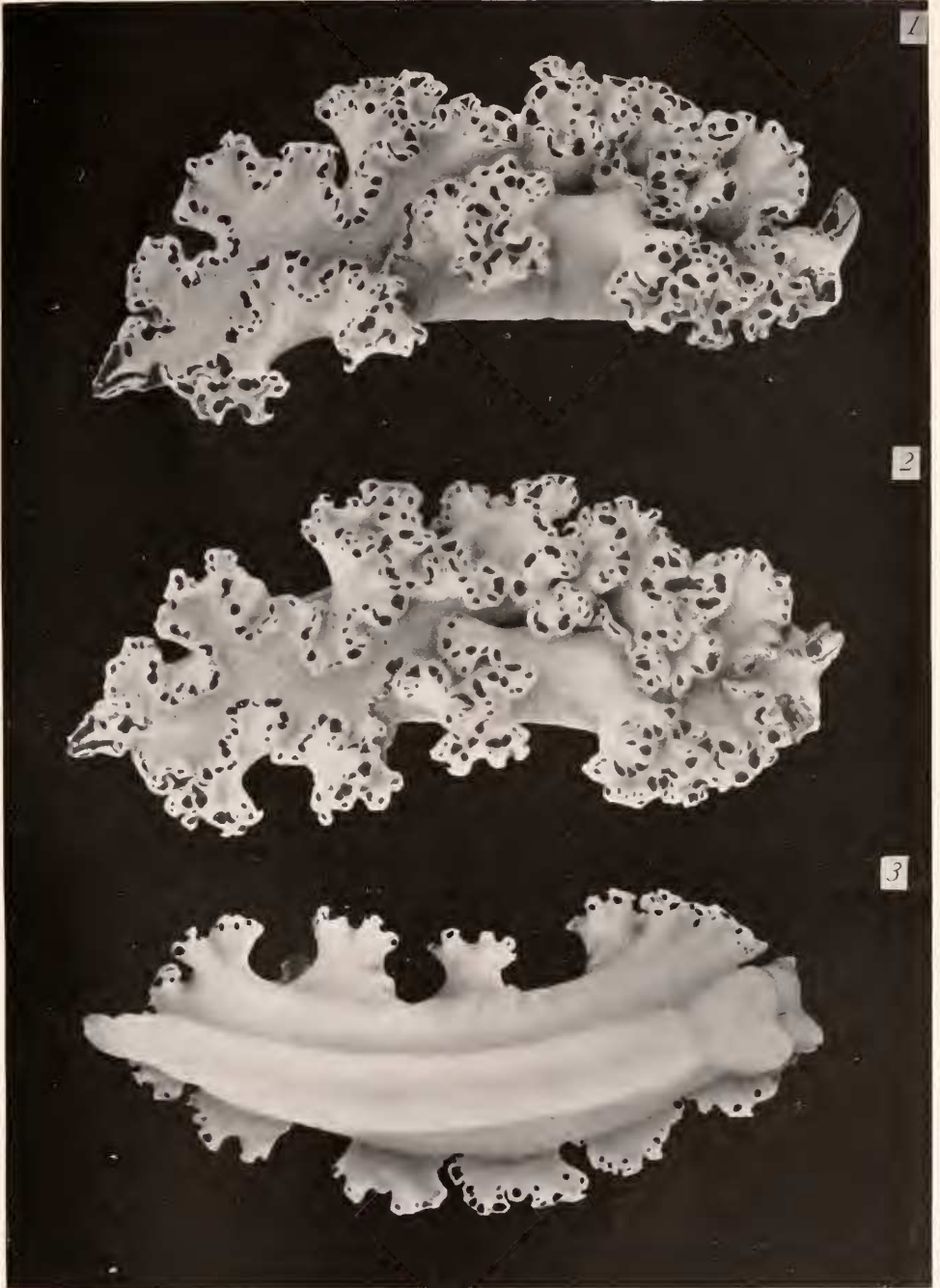


Plate 11

Figs. 1-4. *Tethys parvula* (Guilding, Mörch).

Figs. 5-6. *Aglaia bakeri* MacF. New Species.

- Figs. 1 and 2. Side views from the right of two different specimens. The macerated epithelium has caused considerable haziness in the outlines. X 6.
- Figs. 3 and 4. Dorsal views of the same specimens. X 6.
- Fig. 5. Dorsal view, the tips of the parapodia being reflected outward somewhat. The head shield, toward the top of the figure, is seen quite obliquely, the broad, posterior one much less so. X 5.
- Fig. 6. View of the animal as seen obliquely from the right and below. The rounded foot surface is on the right, its anterior end toward the top of the figure. X 5.

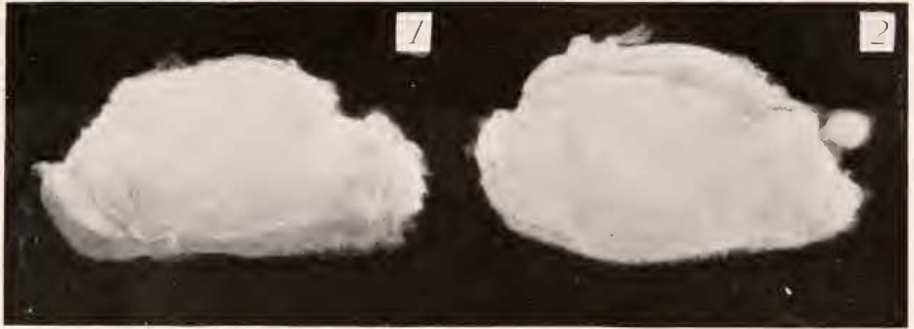


Plate 12

Figures 1-11. *Tethys parvula* (Guilding, Mörch).

- Fig. 1. Half of eleventh row of the radula as seen from above. *c*, median tooth; *l*, first lateral tooth. X 135.
- Fig. 2. Base of the median tooth shown in the preceding figure, seen from below. X 135.
- Fig. 3. Bases of the half row of lateral teeth shown in Fig. 1, as seen from below. *l*, first lateral tooth. X 135.
- Fig. 4. Three individual rodlets from the upper, anterior margin of the labial armature. X 351.
- Fig. 5. Rodlets from the anterior border toward the lower margin of the labial armature. X 351.
- Fig. 6. Surface view of whole, labial armature. *a*, anterior margin. X 17.
- Fig. 7. Shell as seen in profile view from the right side. X 7.
- Fig. 8. Shell as seen in ventral view. X 7.
- Fig. 9. Detail of apex of the shell as seen in ventral view. X 17.
- Fig. 10. Shell as seen in dorsal view. X 7.
- Fig. 11. Hypobranchial or opaline gland (Organ of Bohadsch) as seen from within. The cells of the lobe *a* open through a common duct to the exterior; those of the upper, remaining portion have individual, independent openings. X 17.
- Fig. 12. *Aglaja bakeri* MacF., as seen from behind. The parapodia have been deflected downward and outward, and the tips of the posterior mantle lobes are folded outward against the surface of the body, revealing the posterior opening to the pallial chamber. On the right the outer half of the ctenidium is exposed from beneath the mantle. X 4.

Figures 13-15 *Tridachiella diomedea* (Bergh).

- Fig. 13. Lateral view of the teeth at the summit of the radula angle. The tooth directed downward at the left, the twelfth of the series, is just emerging from the radula sheath. X 45.
- Fig. 14. Second tooth of radula, discarded and inclosed in the ascus at the anterior end of the radula, as seen obliquely from below. X 45.
- Fig. 15. Fourth tooth of the radula in side view, showing the depression on its dorsal surface into which the hook of the preceding tooth fits. X 45.
- Fig. 16. Shell of *Aglaja bakeri* MacF. in dorsal view. The irregular line *a* indicates the boundary of the calcified portion behind and the membranous area in front. The transparency of the membranous area has been lost in the reproduction. X 8.8.
- Fig. 17. Shell of *Aglaja bakeri* MacF. in ventral view, the line *a* marks the boundary of the calcified area as in the preceding figure. X 8.8.



Plate 12—Continued

Figures 18-21, *Tridachiella diomedea* (Bergh).

- Fig. 18. Central nervous system in dorsal view. The large, cerebro-pleural ganglion pair is shown above, immediately behind and in contact with them lie the smaller, parietal ganglia, below and behind the parietal pair is the very large, unpaired visceral ganglion, while the paired pedal ganglia are nearly concealed by the cerebro-pleural ones. The optic nerves are especially long, and terminate in the black eyes, in the figure displaced considerably from their normal positions. X 23.
- Fig. 19. The buccal ganglia in dorsal view, removed from their normal position below the cerebro-pleural ganglia, the cerebro-buccal connectives, *c*, curving forward and upward to unite with the cerebral ganglia. X 23.
- Fig. 20. Dorsal view of the anterior end of the animal, the parapodia being pressed apart to show their anterior terminations on the body wall, in front of the elliptical, reno-pericardial eminence, from beneath which elevated ridges proceed, inclosing the main branches of the liver to the lateral body expansions. *a*, anal opening. *r*, renal opening. X 3.5.
- Fig. 21. View of head of animal from the right side, showing the involute, right rhinophore, the eye immediately behind its base, and, further back, the opening of the oviduct, just in front of the anterior, incurving fold of the parapodium. X 3.5.